

OVERVIEW OF ANALYSIS METHODS OF ROLLING ELEMENT BEARINGS

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Abstract: In many cases, rolling element bearing defect is attributed to be one of the main causes of breakdown in devices. So that impede troubles, continuous condition monitoring is highly recommended. The following paper deals with several analysis techniques of rolling element bearings.

Keywords: condition monitoring, rolling element bearing, signal processing

1. Introduction

Permanent monitoring of machinery has been considered to be an essential and integral part of any modern manufacturing facility [1]. Device monitoring implies periodic or sequential collection and interpretation of data relating to the condition of hazardous components.

Rolling element bearings are important components of most machinery and their operating circumstances influence directly the operation of the entire machinery. Fault detection supports to determine the location of the fault so that corrective activity can be taken and maintenance work can be planned accordingly [2].

2. Rolling element bearing components

Bearing geometry is a crucial factor for identify bearing defects, because for example the geometry of ball bearings specifies the dynamics of the bearing components and their vibration attribute [3].

Generally, a rolling element bearing comprises two rings with a set of elements running in the tracks among the rings. Almost all of them feature cages. The cages decrease wear, friction, provides equivalent spacing and prevents the elements from friction against each other. Rings and rolling elements material are typically made of low-alloyed, through hardening chromium steel. As lubricant supply is burdensome with rolling element bearing geometry, bearings are frequently packed with thick greases and then sealed so that the bearing operates under lubrication. The standard types of a rolling element comprise ball, tapered roller, cylindrical roller, barrel roller and needle roller [4].

3. Condition monitoring methods

Condition monitoring is one possibility of a predictive maintenance program. The information collected can be used to specify machinery problems and corrective actions can then be implemented.

Several methods are used for the perception of bearing condition monitoring. The techniques are broadly classified as acoustic measurements, noise analysis, temperature monitoring, wear debris detection, vibration analysis etc.

3.1. Acoustic measurement

Acoustic measurement is receiving increasing attention in condition monitoring of rolling element bearings. The most effectual acoustic-based bearing health monitoring is acoustic emission. This is a transient impulse generated by the rapid release of strain energy in solid material under thermal or mechanical stress. The perception of cracks is the main application of acoustic emission. Thus, this method can be used as a device for condition monitoring of bearing defects and shaft cracks. The acoustic emission is not influenced or disturbed by other mechanical noise, and defects in rotating machinery, such as misalignment and unbalance, which cannot be eliminated lightly and entirely. So the acoustic emission based methods are superior in certain areas, especially for initial fault detection in rolling element bearings [5]. The acoustic emission process is capable of detecting defects forming deep inside the material, even before it would propagate out to the surface [6]. The measurement of a machine's sound can also be employed for diagnosing defects in bearings. Usually, the precision of these methods depends on sound pressure and sound intensity data [3].

The most frequently used acoustic emission parameters are energy, counts, rms, amplitude and duration time. The representation of acoustic emission parameters illustrated in Figure 1.

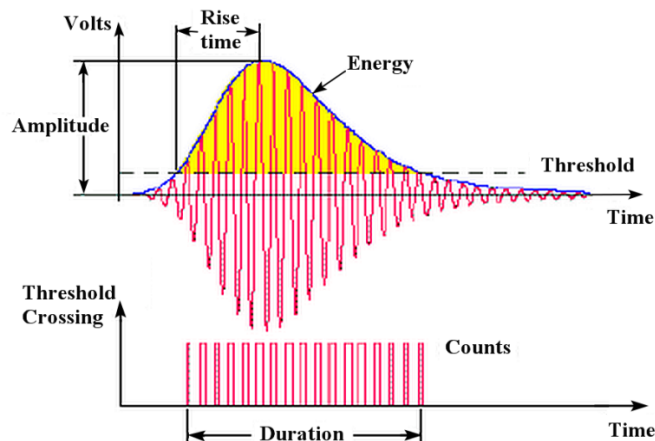


Figure 1. Acoustic emission parameters [7]

3.2. Noise analysis

Even though the most advanced manufacturing technology is used, sound still befall naturally in rolling element bearings. Since the noise emitted by bearings is composed of all types of faults developed during the working time of the bearings and the manufacturing process, the effective values of certain noise quantities enable quick and accurate examination [8].

Race noise is enough elementary sound in rolling bearings. It is a smooth and continuous sound. The magnitude of this noise is used to assess bearing quality. The frequency of this sound does not modify even if rotational speed changes, as shown in Figure 2.

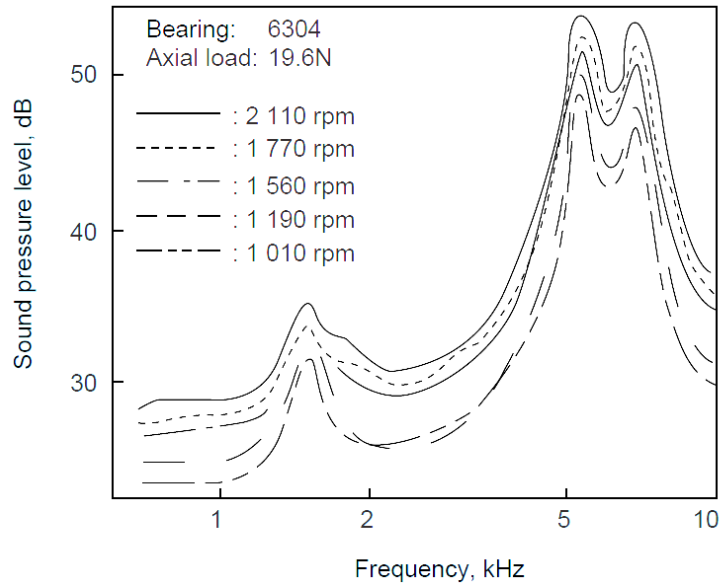


Figure 2. The impact of rotation speed on race noise [8]

Race noise is considered to be caused by configuration mistake, which happens even though the most advanced machining technology is used to process the surfaces of the raceways and rolling elements of a bearing. There are no particular countermeasures to eliminate the race noise entirely, but it can be minimized by perfecting the overall quality and precision of bearings [8].

Squeal noise is a metallic noise that can be rather loud in certain cases. This noise tends to occur with comparatively large bearings used under a radial load. It occurs usually in cylindrical roller bearings, but can also occur in ball bearings [8].

Click noise is generated merely at low speeds and cease when speed exceeds a concrete level. It is the collisions among the rolling elements and the cage and/or inner ring which cause click noise. It tends to occur more frequently in comparatively large bearings under radial loads [8].

Cage noise is attributed to the rotating cage colliding with raceway rings or rolling elements. Since there is clearance among the cage and both the raceway rings and rolling elements, it is cumbersome to fully eliminate cage noise. Nevertheless, it could be reduced to some extent by reducing the mounting mistake [8].

When a defect such as a rust or dent exists on a finished raceway surface of a rolling bearing, then a pulsating, machine-gun-like noise is created if the bearing rotates. In this case the level of the entire frequency spectrum rises [8].

Noise analysis technique can be implemented in conjunction with widely used signature analysis methods like cepstrum analysis, time domain statistics and spectrum analysis to meliorate the overall diagnostic and detection ability of these conventional methods in the presence of severe noise [9].

3.3. Temperature monitoring

Heat emission is a phenomenon that accompanies nearly each dynamic activity. Rolling element bearing distributed defects generate excessive heat in the rotating components. Rolling bearing manufacturers have long been aware of the connection of heat to bearing life and have designed formulas to precisely calculate safe operating temperatures. The outcomes indicate a temperature band in which both lubricants and bearings will operate at top performance with the least stress. As soon as outside the ideal temperature range, they will degrade at an accelerated rate [10].

Figure 3 shows the temperature range of a typical rolling element bearing. The red zone represents the critical section, the yellow zone symbolizes the decreasing lubricant and bearing life, the green zone expresses the sweet spot for bearing and lubrication temperature [10].

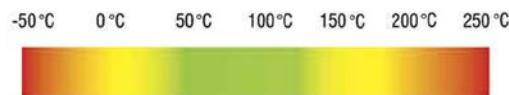


Figure 3. Thermal ranges of rolling element bearings [10]

Exist different temperature bands for distinct combinations of bearing and lubricant, but they will have the identical general trend regarding the optimal operating temperature and its effect on accelerated wear and failure.

Thermal imaging empowers real-time temperature monitoring and localization of temperature increases. Nevertheless, it allows a spatial visualization of heat propagation in monitored areas [11].

3.4. Wear Debris Analysis

The wear progress of a given machine is generally the result of many different, simultaneous wear mechanisms, each of which has its own way of affecting to the machine's operating environment and the changes that occur in it. When the poor operating conditions persist, the wear could either inflict parts of the machine to break or disturb the machine's operation. To allow detection at an untimely phase and control of the wear process, the amount, size, and appearance of wear debris particles in the machine's lubricating oil must be monitored [12].

In this technique, the presence of metallic particles in the lubricant is detected by sensitive sensors. Additionally, the spectrographic analysis of the dissimilar metallic elements in the lubricant could facilitate the location of the defect [3].

3.5. Vibration analysis

Vibration monitoring is a helpful tool in the maintenance. As the anomalous vibration of rotary machines is the first sensory effect of rotary component fault, vibration analysis is extensively employed in the industry. Vibration analysis could be applied for the diagnosis of every type of faults even distributed or localized. Among other things the vibration measurement methods benefits are accurate results, low-cost sensors and specific information [3].

Vibration analysis techniques are Fourier-transform, artificial neural networks, fuzzy logic systems, Wavelet-transform, Wigner–Ville distribution, singular spectrum analysis and so on.

4. Conclusion

Several diverse methods have been evolved for monitoring and diagnosis of rolling element bearings in the past decades. Vibration based methods are well established for the condition monitoring of rolling element bearings, although they are not so effectual in detecting early defects in the bearing. Acoustic emission is receiving increasing attention as a complementary method for condition monitoring of bearings as acoustic emission is enough sensitive to incipient defects. Temperature monitoring of bearing is a quick method for fault perception in rotary machines.

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